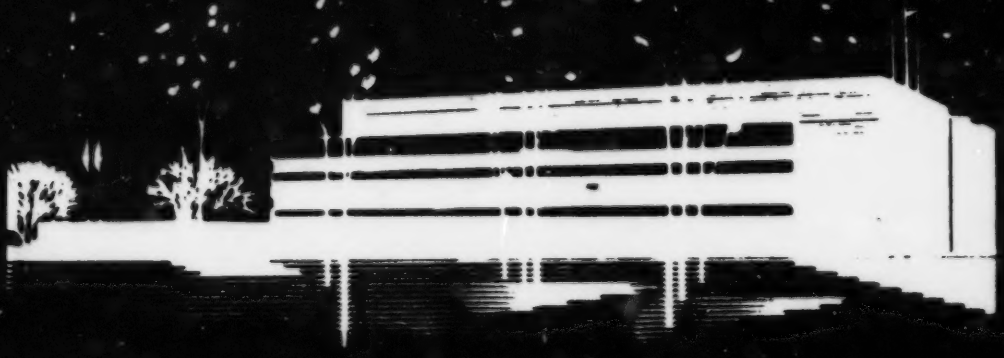
PROGRAM REVIEW

Great Lakes Forest Research Centre

1984 - 85



86-0612/

PROGRAM REVIEW

GREAT LAKES FOREST RESEARCH CENTRE

CANADIAN FORESTRY SERVICE

GOVERNMENT OF CANADA

1984-85

©Minister of Supply and Services Canada 1985
Catalogue No. Fo41-12/1985E
ISBN 0-662-14083-4
ISSN 0822-1650

Additional copies of this publication are available at no charge from:
Great Lakes Forest Research Centre
Canadian Forestry Service
Government of Canada
P.O. Box 490
Sault Ste. Marie, Ontario
P6A 5M7

THE CANADIAN FORESTRY SERVICE

GOVERNMENT OF CANADA

The Canadian Forestry Service (CFS) is the principal source of federal expertise in forestry. Its general objective is to promote the wise management and use of Canada's forest resources for the economic, social, and environmental benefit of Canadians.

The following are the main functions of the CFS:

1. coordination of federal policies, for the promotion of better resource management and forest industry development;
2. provision of scientific and technological leadership in forestry through research and development;
3. Provision and analysis of national and international statistics and information as a basis for policy formulation;
4. development and certification of codes and standards for wood product performance;
5. protection of Canada's forests from foreign pests;
6. fostering the potential use of the forest resource for energy;
7. contributing to the environmental objectives of the government of Canada.

A number of federal agencies are involved in forestry programs and a Federal Forest Sector Strategy Committee has been established to coordinate federal forestry activities. The CFS has been designated the lead agency.

The CFS comprises a headquarters unit, six forest research centres, and two national institutes. The forest research centres are responsive to regional priorities and maintain close liaison with the respective provincial government forestry departments and other clients. They also participate in, and frequently lead, national programs. The national institutes provide the focus for programs of national scope.

SERVICE CANADIEN DES FORÊTS
GOUVERNEMENT DU CANADA

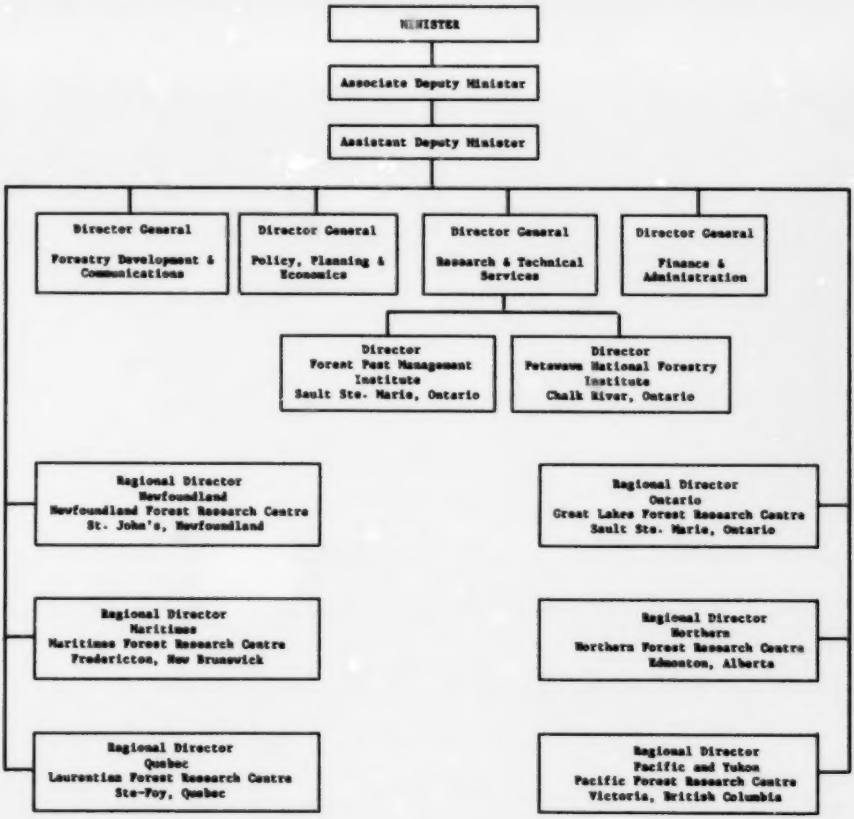
Le Service canadien des forêts (SCF) réunit la majorité des spécialistes fédéraux en foresterie. Son objectif général est de promouvoir l'aménagement et l'utilisation judicieux des ressources forestières du Canada pour le plus grand bien économique, social et environnemental des Canadiens.

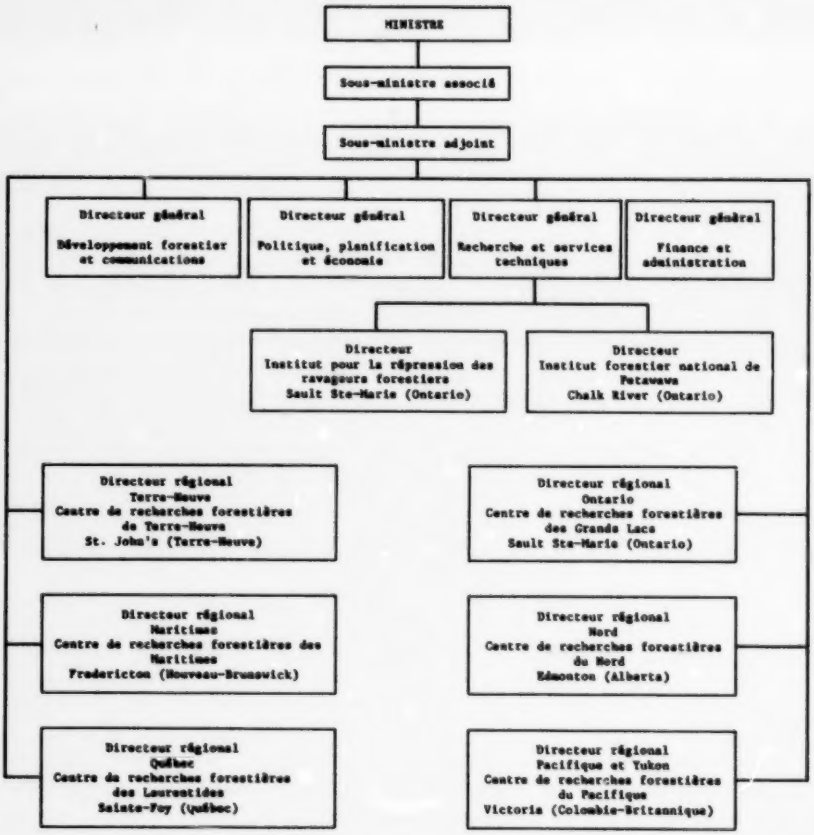
Voici les principales fonctions du SCF:

1. coordonner les politiques fédérales afin de favoriser l'amélioration de la gestion des ressources et l'expansion de l'industrie forestière;
2. fournir une orientation scientifique et technologique dans le domaine de la foresterie, par la recherche et le développement;
3. fournir et analyser les statistiques et l'information nationales et internationales qui serviront à établir les politiques;
4. mettre au point et homologuer des codes et des normes en matière de rendement des produits du bois;
5. protéger les forêts canadiennes en luttant contre les ravageurs étrangers;
6. parrainer l'utilisation éventuelle des ressources forestières pour la production d'énergie;
7. adhérer aux objectifs environnementaux du gouvernement fédéral.

Divers organismes fédéraux participent aux programmes forestiers, et un comité stratégie forestière fédérale a été créé pour coordonner les activités fédérales en matière de foresterie. Le SCF a été désigné organisme directeur.

Le SCF comprend une administration centrale, six centres de recherches forestières et deux instituts nationaux. Les centres de recherches forestières doivent répondre aux impératifs régionaux et entretenir une liaison étroite avec les ministères provinciaux des Forêts. Ils participent également à des programmes nationaux dont ils assument fréquemment la direction. Les instituts nationaux sont les foyers des programmes d'envergure nationale.


MINISTER
Associate Deputy Minister
Assistant Deputy Minister
Director General
Forestry Development & Communications
Director General
Policy, Planning & Economics
Director General
Research & Technical Services
Director General
Finance & Administration
Director
Forest Pest Management Institute
Sault Ste. Marie, Ontario
Director
Petawawa National Forestry Institute
Chalk River, Ontario
Regional Director
Newfoundland
Newfoundland Forest Research Centre
St. John's, Newfoundland
Regional Director
Ontario
Great Lakes Forest Research Centre
Sault Ste. Marie, Ontario
Regional Director
Maritimes
Maritimes Forest Research Centre
Fredericton, New Brunswick
Regional Director
Northern
Northern Forest Research Centre
Edmonton, Alberta
Regional Director
Quebec
Laurentian Forest Research Centre
Ste-Foy, Quebec
Regional Director
Pacific and Yukon
Pacific Forest Research Centre
Victoria, British Columbia


MINISTRE
Sous-ministre associé
Sous-ministre adjoint
Directeur général
Développement forestier et communications
Directeur général
Politique, planification et économie
Directeur général
Recherche et services techniques
Directeur général
Finance et administration
Directeur
Institut pour la répression des ravageurs forestiers
Sault Ste-Marie (Ontario)
Directeur
Institut forestier national de Petawawa
Chalk River (Ontario)
Directeur régional
Terre-Neuve
Centre de recherches forestières de Terre-Neuve
St. John's (Terre-Neuve)
Directeur régional
Ontario
Centre de recherches forestières des Grands Lacs
Sault Ste-Marie (Ontario)
Directeur régional
Maritimes
Centre de recherches forestières des Maritimes
Fredericton (Nouveau-Brunswick)
Directeur régional
Nord
Centre de recherches forestières du Nord
Edmonton (Alberta)
Directeur régional
Québec
Centre de recherches forestières des Laurentides
Sainte-Foy (Québec)
Directeur régional
Pacifique et Yukon
Centre de recherches forestières du Pacifique
Victoria (Colombie-Britannique)

Regional Director: J.H. Cayford
Deputy Director and Program Director, Forestry Development: R.A. Haig
Program Director, Research and Technical Services: C.R. Sullivan
Research Manager, Forest Resources: L.F. Riley
Research Manager, Environmental Forestry and Fire: I.K. Morrison
Support Staff: G. Londry, H.M. MacDonald, M.C. Ruprechter

Chief of Management Services: R.M. Dean (1984), M.J. Parent (1985)
Chief, Socio-economic Analysis and Planning: J.H. Smyth
Head, Scientific and Technical Information Services: C.A. Plexman
Management Advisor, Research and Technical Services: G.D. Huntley
Chief Implementation Officer: D.W.J. McGowan

FOREWORD

The Great Lakes Forest Research Centre (GLFRC), located in Sault Ste. Marie, Ontario, is one of six regional forestry centres operated by the Canadian Forestry Service. The service is the principal source of federal expertise in forestry and its general objective is to promote the wise management and use of Canada's forest resource for the economic, social and environmental benefit of Canadians. The main activities of the Service include research and development, management of federal-provincial forest resource development agreements, a national statistics program and coordination of federal policies to promote forest industry development, improved resource management and greater employment opportunities in the forestry sector. GLFRC is responsible for the federal forestry program in Ontario.

From its inception in 1965, GLFRC has been involved in forestry-related research and associated technical services. In 1982-83, the Centre also assumed responsibility for the federal management and administration of federal-provincial forestry agreements and for forestry job creation programs.

Two Program Directors are responsible for the management of our forestry programs. The Program Director for Research and Technical Services is C.R. Sullivan and the Program Director for Forestry Development is R.A. Haig. Mr. Haig also serves as Deputy Director.

Our research program includes three subprograms: forest resources, forest protection and environmental forestry. These deal directly with the issue of maintaining the resource supply, through research aimed primarily at increasing regeneration and reducing losses but also at increasing yields per hectare and increasing utilization. In combination with these undertakings, we are also directing our research toward the maintenance of a quality environment. Our activities range from basic to applied and developmental research and include a significant element of technology transfer to our major clients. Within our three subprograms we have identified nine projects, each of which comprises discipline-oriented studies.

Major activities in forestry development include the federal management responsibility for federal-provincial forest management agreements, management of forestry job creation programs, participation in the National Forestry Statistics program, and forest economics research.

Much of our research is carried out in cooperation with the province of Ontario. Under a Canada-Ontario agreement, a Canada-Ontario Joint Forestry Research Committee (COJFRC) is responsible for coordinating, planning and implementing forest research programs carried out by both governments. Our mechanization of

silviculture project is guided by a National Advisory Committee on Mechanization of Silviculture (NACMEC), while at year-end a GLFRC Advisory Committee was being established.

The 1984-85 Program Review outlines our accomplishments for the year and our major goals for 1985-86. A major highlight during the year was the signing by federal and provincial ministers of the Canada-Ontario Forest Resource Development Agreement. This $150 million 5-year agreement has as its focus forest renewal and intensive forest management. Most of this agreement involves bilateral delivery; however, each government provides $14 million for direct delivery projects.

The Great Lakes Forest Research Centre-Forest Pest Management Institute expansion program continued during the year, with major additions to the laboratory complex and administrative wing. During the year, GLFRC successfully concluded its Environment 2000 forestry job creation program. In all, 1,350 jobs were provided, with a total expenditure of $5.8 million. Major sponsors included conservation authorities, private contractors, municipalities and charitable organizations. A number of activities were carried out in conjunction with National Forest Week, 6-12 May 1984. These included a ministerial visit, a tree planting ceremony in the arboretum, an open house, publication of a GLFRC forestry supplement in a local weekly newspaper, and a transit shelter poster campaign in major southern Ontario cities. Staff of the Centre played leading organizational and participatory roles in several major conferences, including the CANUSA spruce budworm research meeting in Bangor, Maine, a white pine symposium held in conjunction with the 121st annual meeting of the Entomological Society of Ontario, a mechanization of silviculture seminar held at the Canadian Pulp and Paper Association's Woodlands Equipment Demonstration in Thunder Bay, and the COJFRC symposium on forest fire management. Research agreements were signed during the year with the School of Forestry, Lakehead University and the Faculty of Forestry, University of Toronto, and communications with the North Central Forest Experiment Station in St. Paul, Minnesota were increased through exchange visits of management and research staff.

In 1984-85 two entomology projects, GLC-08, Spruce Budworm Control Research, and GLC-10, Insect Control, Biological Methods, were integrated into a new project, GLC-32, Development and Application of Concepts in Forest Entomology in Ontario. Two pathology projects, GLC-06, Gremmeniella Diseases of Conifers, and GLC-07, Management of Boreal Mixedwood, Pathology Aspects, were similarly integrated into a new project, GLC-31, Forest Pathology Research. No other projects were initiated or terminated.

In 1984-85 our total expenditures were $27.6 million, and we had a full-time staff of 164. Several personnel changes occurred during the year. G. King, Shift

Engineer, and Z. Moynan, Secretary, retired. Transfers included R.M. Dean, Chief of Management Services, to the Pacific Forest Research Centre, J. Régnière, Research Scientist, to the Laurentian Forest Research Centre, L. F. Weist, Information Clerk, to Taxation Canada in Sudbury, and J. C. Lalonde, Information Officer, to the office of the Minister of State (Forestry). D.P. Webb, Research Scientist, and B. McMurray, Inventory Clerk, resigned during the year. Staff additions during the year included M.J. Parent, Chief of Management Services, and G.M. Wickware, Land Resource Scientist.

J.H. Cayford, Regional Director
Great Lakes Forest Research Centre
31 March 1985

TABLE OF CONTENTS

	Page
FOREST ENVIRONMENT RESEARCH	1
Impact of Long-range Transport of Air Pollutants on the Biogeochemistry of Forest Ecosystems	3
FOREST PRODUCTION RESEARCH	5
Black Spruce Ecosystem Silviculture	7
Mechanization of Silviculture	8
Reforestation Silviculture	9
FOREST PROTECTION RESEARCH	11
Forest Fire Research	13
Gremmeniella Diseases of Conifers	14
Boreal Mixedwood Pathology	15
Spruce Budworm Control Research	16
Insect Control Research Emphasizing Biological Methods	17
FOREST UTILIZATION RESEARCH	19
Energy from Forest Biomass	21
FORESTRY SERVICES	23
Forest Insect and Disease Survey	25
Forest Resources Data	26
Liaison, Development and Technical Services	27
Economic Studies and Development	28
FORESTRY DEVELOPMENT	29
Development Agreements	31
Employment Stimulation	32

(continued)

TABLE OF CONTENTS (concluded)

Page

ADMINISTRATION, FINANCIAL SERVICES AND PROPERTY MANAGEMENT . . 33

BIOMETRICS AND APPLIED SOFTWARE SERVICE AND COMPUTER FACILITIES AND SERVICES 37

RESEARCH AND TECHNICAL SUPPORT SERVICES 41

SCIENTIFIC AND TECHNICAL INFORMATION SERVICES 45

APPENDICES 49

Organization Chart 51

Expenditures 52

Contracts Let or Supervised by the Great Lakes Forest Research Centre 53

Publications 55

Forest Environment Research

IMPACT OF LONG-RANGE TRANSPORT OF AIR POLLUTANTS ON THE BIOGEOCHEMISTRY OF FOREST ECOSYSTEMS

Professional Staff: N.W. Foster (Project Leader), G.D. Hogan, J.A. Nicolson, R.D. Whitney

Support Staff: L. Chartrand, P.W. Hazlett, R. Irwin, A.W. Johns, D.J. Kurylo, D. Ropke

Objectives

To elucidate the influence of atmospheric deposition of acidifying substances on tree form and function, tree diseases, nutrient cycles and hydrologic processes in Ontario forests.

Achievements

Completed a fourth year of uninterrupted measurement of water quality within 20 terrestrial sub-basins at Turkey Lakes Watershed; completed a facility for carrying out studies on the physiological effects of acid rain and began experiments; determined ion transport through the soil at two sites in the watershed; began a field experiment to test the effect of simulated rain of various acidities on Armillaria root rot inoculated in young balsam fir trees; published three journal articles and made four presentations at scientific conferences.

Goals for 1985-1986

To participate in the International Symposium on Acid Rain, sponsored by the provincial and federal governments, in Muskoka, Ontario in September 1985 and the NATO Advanced Research Workshop on Effects of Acidic Deposition and Atmospheric Pollution on Forests, Crops and Wetlands in May 1985; to report on the production/consumption of N and S in podzolic soils and the input-output of major ions by small terrestrial feeder streams in the Turkey Lakes Watershed; to carry out growth chamber experiments aimed at determining the morphological and physiological effects of simulated acid rain on native hardwoods; to apply simulated acid rain to trees protected from rain and monitor disease development on Armillaria-inoculated and untreated trees.

Forest Production Research

BLACK SPRUCE ECOSYSTEM SILVICULTURE

Professional Staff: R.A. Sims (Project Leader), R.L. Fleming, A. Groot, V.F. Haavisto, J.K. Jeglum, B. Payandeh, G.M. Wickware

Support Staff: M.J. Adams, G.T. Atkinson, G.J. Koteles, D. Mossa, R. M. Siltanen, S. Taylor

Objectives

To develop a classification system for black spruce ecosystem types in Ontario for forest management purposes; to determine if modified cutting and direct seeding are feasible alternatives to clearcutting and planting for regenerating black spruce; to determine the feasibility of intensive treatments such as drainage and fertilization to increase productivity on black spruce peatlands; to determine the impact of current forest management practices on black spruce ecosystems.

Achievements

Undertook a second field program in a cooperative CFS-Ontario Ministry of Natural Resources (OMNR) forest ecosystem classification (FEC) and worked at defining soil and vegetation classes for two broad areas within Ontario's North Central Region; prepared a report on the distribution of advance growth according to FEC types in the Clay Belt; continued work on shallow-soil black spruce stands, publishing reports on seedling-seedbed relationships and regeneration trials; cooperated with OMNR in a pilot drainage experiment in Cochrane District; continued investigations of direct seeding on upland and lowland sites, the effects of site preparation on upland sites, advance growth in peatlands, conifer seed treatments to delay or speed up the effects of germination in shallow-soil black spruce stands, growth and yield, and cone and seed production.

Goals for 1985-1986

To analyze and interpret FEC data from the Clay Belt and North Central Region studies, and undertake a field program in a third major area in the North Central Region; to remeasure trials for advance growth and seeding studies; to analyze fifth-year data on blowdown in strip cuts and prepare a report on additional regeneration results in shallow-soil black spruce stands; to prepare a literature review on black spruce regeneration; to begin microenvironmental studies of seedbed microsites so as to improve understanding of seedling growth and survival; to prepare a report on upland scarification trials; to continue work on cone and seed production, growth and yield, lowland forest drainage and conifer seed treatments.

MECHANIZATION OF SILVICULTURE

Professional Staff: C.R. Smith (Project Leader), J-D. Leblanc, B.J. Sutherland

Support Staff: F.F. Foreman, D.J. Kennington, J. Richenhaller

Objectives

To develop biologically sound mechanized techniques for the efficient and effective conduct of silvicultural operations in Canada; to develop and maintain agencies in Canada to promote and foster the application of mechanized silvicultural techniques.

Achievements

Carried out a cooperative field evaluation of the Bracke Mounder scarifier in Quebec; assisted in setting up an evaluation of four slash raking implements in Newfoundland; presented two papers and assisted in organizing a joint Canadian Pulp and Paper Association (CPPA)/CFS seminar on mechanization of silviculture; in cooperation with OMNR, demonstrated standard silvicultural equipment assessment procedures at the CPPA woodlands equipment field demonstration; presented two papers at a mechanization of silviculture workshop in Alberta; produced two issues of the Mechanization of Silviculture Newsletter.

Goals for 1985-1986

To organize an International Union of Forestry Research Organizations (IUFRO) working party meeting to consider current research developments with respect to the advancement of mechanized stand establishment; to publish a standard assessment procedure for evaluating silvicultural equipment; to conduct an evaluation of the Great Lakes Forest Products powered head scarifier.

REFORESTATION SILVICULTURE

Professional Staff: F.W. von Althen (Project Leader), J.B. Scarratt, R.F. Sutton, D.P. Webb, J.E. Wood

Support Staff: B.R. Canning, F.W. Curtis, D.L. Marles, E.G. Mitchell, T.P. Weldon

Objectives

To develop regeneration methods and associated tree growing techniques for efficient and effective stand establishment and treatment; to develop biologically sound techniques for conducting silvicultural operations in Canada.

Achievements

Excavated seedlings in a 9-year-old spruce plantation to determine the effects of five different types of containers on seedling growth performance and root morphology; in cooperation with OMNR, published an operational manual for monitoring frost hardiness and needle primordia initiation of spruce container stock hardened off for overwinter storage by the Extended Greenhouse Culture System; prepared the section on forestry for the National Research Council's project aimed at developing a detailed examination of the applicability of cost-risk benefit analyses to organic chemical use in Canada.

Goals for 1985-1986

To conduct eighth-year remeasurements of experiments so as to compare growth performance of different grades of black spruce and jack pine containerized planting stock; to complete a study on the comparative field performance of coniferous bare-root and paperpot black spruce planting stock; to collect 10-year data in spacing studies of planted black walnut, white ash and silver maple and report on the results; to complete a major study on establishment of coniferous plantations in the boreal forest by conventional planting of bare-root stock; to complete a study on planting season extension by comparison of the outplant performance of cold-stored and fresh-planted black walnut, red oak and silver maple seedlings.

Forest Protection Research

FOREST FIRE RESEARCH

Professional Staff: B.J. Stocks (Unit Head), T.J. Lynham, D.J. McRae

Support Staff: T.W. Blake, G.R. Hartley, J.A. Mason

Objectives

To coordinate GLFRC fire research activities as part of Ontario's fire management program and to participate in the CFS national program; to develop improved presuppression techniques by means of fuel-specific fire behavior models for major fuel types and by performance analysis and calibration of the Canadian Forest Fire Danger Rating System for Ontario conditions; to determine the ecological effects of prescribed fire and wildfire on forest ecosystems and relate these to fire behavior parameters.

Achievements

Initiated an investigation of fire growth from a point-source ignition by establishing burning plots in immature jack pine and jack pine slash and by undertaking 12 successful fires; produced in cooperation with other CFS fire researchers, a Fire Behavior Prediction System for major Canadian fuel types; completed a 2-year investigation of historical fire periodicity in the Sachigo Hills area of northwestern Ontario; organized the 1984 COJFRC symposium on forest fire management; published papers on fire behavior in spruce budworm-killed balsam fir, the behavior and impact of prescribed fire in the Clay Belt region of northern Ontario, the use of prescribed fire to convert balsam fir stands to more budworm-resistant species, and the fire environment in Pukaskwa National Park.

Goals for 1985-1986

To complete the point-source ignition burning program in immature jack pine and jack pine slash; to continue monitoring and documenting fire behavior in major Ontario wildfires and operational prescribed burns; to analyze fire effects data (vegetation succession, nutrient cycling) on all experimental and well documented wildfires and report results; to participate in a CFS national burning project in northern Alberta, and continue, as part of the CFS fire danger group, to update and expand the Canadian Forest Fire Danger Rating System; to publish articles on fire behavior in mature and immature jack pine and budworm-killed balsam fir, prediction of the occurrence of man-caused fires in Ontario, and the CFS cooperative fire behavior study in the Northwest Territories.

GREMMENIELLA DISEASES OF CONIFERS

Professional Staff: C.E. Dorworth (Project Leader), S. Takai

Support Staff: C.N. Davis, W.C. Richards

Objectives

To develop ecologically satisfactory techniques for control of each race of *Gremmeniella abietina* as it attacks conifers and correlate disease syndromes with inceptive races; to investigate the biochemistry, genetics and physiology of *G. abietina* so as to understand the host-parasite interaction and develop control methods.

Achievements

With experience gained in Europe, inoculated several host and non-host tree species in New Brunswick with local isolates of *G. abietina* in a study of the mechanisms of host resistance and pathogen colonization of host tissue; serotyped over 200 isolates of the *G. abietina* pathogen and identified the virulent European race as widespread along the Quebec side of the Quebec-Ontario border; initiated extensive screening of *Ceratocystis ulmi* plasmids and determined their significance by using isolates of known pathogenicity.

Goals for 1985-1986

As part of the reorganized project on forest pathology research, to assess field inoculations done during 1984 in New Brunswick; to continue monitoring collections of *G. abietina* from Quebec and Ontario, to detect any incursions of the European race into Ontario, and to permit mapping of existing locations in other areas; to adapt the monoclonal antibody technique for use with races of *G. abietina* and for associating *G. abietina* with other pathogenic Helotiaceae; to continue screening *C. ulmi* plasmids and examine their relationship to character expression, e.g., cerato-ulmin production and pathogenicity.

BOREAL MIXEDWOOD PATHOLOGY

Professional Staff: J.T. Basham (Project Leader), J.T.M. Dumas, R.D. Whitney

Support Staff: W.E. Britnell, R. Broadbent, R.N. Irwin

Objectives

To develop silvicultural and management procedures and biological control methods to minimize the impact of root rot, stem decay and stem deterioration on the boreal mixedwood forest of Ontario, and to disseminate the acquired knowledge to potential users.

Achievements

Discovered that the major cause of root rot in Ontario, previously believed to be *Armillaria mellea*, is at least three distinct biological species; developed a technique for distinguishing *Armillaria* isolates; retallied mortality due to root rot on 26 young conifer plantations; analyzed data on mortality, windfall and butt rot in spruce and balsam fir caused by root rot; published results of a study on degradation and loss of wood fiber in budworm-killed timber and effects on utilization; isolated many bacteria, actinomycetes, and fungi that were antagonistic to some of the major causes of stem decay and root rot in the boreal mixedwood forest of Ontario.

Goals for 1985-1986

As part of the reorganized project on forest pathology research, to assess the extent of stem decay and stain in young aspen stands that were scarified soon after sucker development, to collect more *Armillaria* basidiocarps, and to increase our knowledge of the range and identity of species in Ontario; to isolate soil microorganisms and assess their antagonism towards major tree decay fungi; to publish information on windfall, butt cull, and mortality caused by root rot in the boreal mixedwood forest of Ontario; to publish a report on the toxicity of mansonones A, C, D, E, F and G to the fungus responsible for Dutch elm disease.

SPRUCE BUDWORM CONTROL RESEARCH

Professional Staff: C.J. Sanders (Project Leader), G.T. Harvey, J. Régnière (1984)

Support Staff: R.M. Fletcher, G.S. Lucuik, P.M. Roden

Objectives

In cooperation with other CFS research centres, to provide information required by forest managers on budworm control, particularly in Ontario; to evaluate and, where appropriate, develop to an operational level, acceptable methods of regulating budworm populations.

Achievements

Completed experiments leading to the selection of a sex pheromone trap and lure to monitor long-term fluctuations in spruce budworm populations and established protocols for their operational use; continued detailed field investigations of survival of spruce budworm populations to identify key workability factors; analyzed isoenzymes to explore variations among populations of *C. fumiferana* and other forest insects; prepared an extensive review of the taxonomic status of the genus *Choristoneura*.

Goals for 1985-1986

To develop a team approach to the investigation of biological control techniques, with all entomology research at GLFRC being done under a single project; to continue detailed studies on spruce budworm survivorship.

INSECT CONTROL RESEARCH EMPHASIZING BIOLOGICAL METHODS

Professional Staff: D.R. Wallace (Project Leader), D.B. Lyons, V.G. Nealis

Support Staff: Z.M. Faux, S. Fera, D.L. Oliver

Objectives

To develop economically acceptable methods for regulating insect numbers with minimal disruption of the environment, and to demonstrate the applicability of such methods to forest management in Ontario.

Achievements

Continued a study on the biology of the pine false webworm and the impact of its feeding on red pine growth and mortality; examined the phenology and behavior of *Apanteles fumiferanae*, one of the principal parasitoids of the spruce budworm, in an effort to understand the natural control of the pest; continued monitoring egg parasitoids of the gypsy moth and made a small release of a tachinid larval parasitoid; a University of Guelph PhD student continued studies on insect pests of black spruce cones and seeds; provided spruce budworm egg clusters for *Trichogramma* work related to the spruce budworm at the Universities of Guelph and Toronto.

Goals for 1985-1986

As part of the reorganized project on the development and application of concepts of forest entomology in Ontario, to expand studies on *Apanteles fumiferanae* and other spruce budworm parasitoids to include a comparison of their behavior in the jack pine budworm system; to cooperate with a post-doctoral fellow who will begin work on parasitoid behavior, to continue pine false webworm investigations and prepare a dissertation based on the results; to complete doctoral work (University of Guelph PhD student) on black spruce cone and seed insects and write a thesis; to release a tachinid larval parasitoid, *Ceranthia samarensis*, against the gypsy moth; to amalgamate the biological control project and the spruce budworm control research project and develop some new studies.

Forest Utilization Research

ENERGY FROM FOREST BIOMASS

Professional Staff: B.J. Sutherland (Project Leader)

Support Staff: D.J. Kennington

Objectives

To develop and test prototype equipment for the collection and comminution of forest biomass in the forest; to evaluate the potential of forest biomass as an alternative source of energy.

Achievements

Completed the following under contract: the field testing of the first prototype of the Crabe combine, a smallwood harvester for the reclamation of brushlands and the use of brushwood materials as fuel stock for energy production; the yard testing of a logging residue processor, designed to comminute harvesting residue accumulated at landings for energy purposes; the field testing of the Roll splitter prototype, designed to fiberize or crush and dewater woody biomass material for preparation as fuel; a study to quantify the biomass, branch or top material attached to tree stems that was recovered by two harvesting systems in jack pine; a study to assess the problems and current technology in the transportation of full trees over long distances on public roads; a study to investigate the use of compaction systems in conjunction with the harvesting and transportation of forest biomass.

Goals for 1985-1986

To undertake a study to examine the effects of forest land drainage on peat geochemistry, subsidence and water quality and quantity; to complete all final reports on prototype equipment development contracts and to transfer the technology to potential users.

Forestry Services

FOREST INSECT AND DISEASE SURVEY

Professional Staff: G.M. Howse (Unit Head), H.L. Gross, J.H. Meating, D.T. Myren, K. Nystrom, D.B. Roden, P.D. Syme

Support Staff: M.J. Applejohn, C.A. Barnes, W.D. Bigge, H. Brodersen, D.C. Constable, L.R. Cree, E.J. Czerwinski, E.B. Dorworth, H.J. Evans, C. Handfield (1985), W.A. Ingram, V. Jansons, A. Johnson (1985), C.G. Jones, A.J. Keizer, H.D. Lawrence, L.S. MacLeod, R.K. McCron, Z. Moynan (1984), R.J. Sajan, B.E. Smith, M.J. Thomson.

Objectives

To provide information on the kind, severity, extent and impact of insect and disease problems in Ontario; to provide forest managers with information needed for decision making on control operations; to advise and assist the province in planning and evaluating control operations; to improve procedures used in insect and disease surveys and assessments; to elucidate the bionomics of little-known forest pests.

Achievements

Conducted aerial and ground surveys of the incidence of, and damage caused by, major forest pests in Ontario, identifying nearly 2400 insect and 1400 disease samples and answering about 2400 inquiries; conducted special surveys of pest problems in plantations, seed orchards, seed production areas, provincial and national parks and high-value commercial timber stands; assessed provincial spraying operations and trials against spruce budworm on 3700 ha in Hearst District; began or continued studies of the effects of specific insects or diseases on tree health.

Goals for 1985-1986

To conduct annual surveys of, and report on, major forest pest problems in Ontario; to publish a report on the impact of forest insects and diseases in Ontario forests from 1977 to 1981; to complete the manuscript of Tree Diseases of Eastern Canada; to conduct surveys for pests of red pine and jack pine plantations, seeds and cones; to participate in an early warning system for acid rain by monitoring damage caused in Ontario forests; to assess spraying operations conducted against spruce budworm, jack pine budworm and gypsy moth.

FOREST RESOURCES DATA

Professional Staff: J.H. Smyth (Project Leader)

Support Staff: K.L. Ramsay-Campbell

Objectives

To provide forestry statistics required by the federal government in planning its programs and fulfilling its forestry obligations.

Achievements

Updated and expanded the Ontario forest statistics information base; completed and distributed reports on forest tree production centres in Canada (1983), forest management expenditures in Canada (1977-1981), and selected forestry statistics for Ontario; began updating forest management expenditures for Canada for the period 1982-1984.

Goals for 1985-1986

To publish reports on forest management expenditures in Canada, forest tree production centres in Canada, and corporate and other revenues generated by the Ontario forest industry; to compile and report on the status of forest industry labor settlements in 1984-1985.

LIAISON, DEVELOPMENT AND TECHNICAL SERVICES

Professional Staff: C.R. Smith (Project Leader), J-D. Leblanc, B.J. Sutherland

Support Staff: F.F. Foreman, D.J. Kennington, J. Richenhalier, F.W. Curtis

Objectives

To undertake, on behalf of the Centre, activities not directly related to existing forestry or environmental programs; to provide advisory operational and technical support services to research staff and other agencies.

Achievements

Maintained forest management services for CFB Borden; continued development and maintenance of the GLFRC arboretum; maintained low-level involvement in Christmas tree research; provided advisory and technical services to researchers at GLFRC.

Goals for 1985-1986

To complete a long-range management plan for CFB Borden.

ECONOMIC STUDIES AND DEVELOPMENT

Professional Staff: J.H. Smyth (Project Leader), S. Andersen, J.D. Johnson

Support Staff: A.J. Brownwright, K.L. Ramsey-Campbell

Objectives

To study the economic aspects of forest management and industry issues; to provide input into federal policy initiatives in forest management and forest industry development; to provide economic rationale in the development of Canada-Ontario forestry agreements; to provide economics input into program and project evaluation at GLFRC and elsewhere in the Department; to provide advice to other federal departments, provincial government agencies, and private industry on programs concerned with forest management or forest industry development that are beyond the scope of current GLFRC programs.

Achievements

Completed draft manuscript on Ontario's pulp and paper industry, the corporate ownership structure of Ontario's pulp and paper industry, and the medium-term outlook for the Ontario newsprint industry; completed reports on the effect of tariff reductions on the Canadian fine paper industry, the economics of pre-commercial thinning in jack pine, and a cooperative GLFRC/OMNR study to develop a computer-based program to rank silvicultural projects in terms of the present net worth concept; prepared internal documentation related to the Canada-Ontario Forest Resource Development Agreement.

Goals for 1985-1986

To complete a study of the corporate ownership structure of Ontario's pulp and paper industry, a profile of Ontario's pulp and paper industry, the medium-term outlook for the Ontario newsprint industry, backlog treatment as a means of reducing costs of delivered wood in northern Ontario, and value added in the Ontario forest products sector; to prepare a report on the impact of spruce budworm on timber supply in a selected forested area in northwestern Ontario.

Forestry Development

DEVELOPMENT AGREEMENTS

Professional Staff: D.W.J. McGowan (Project Leader), A.J.F. Ballak, R.L.F. Macnaughton

Objectives

To cooperate with OMNR in the management and administration of the Forest Management Subsidiary Agreement (FMSA) and the Canada-Ontario Forest Resource Development Agreement (COFRDA) and to monitor progress and expenditures for both; to ensure adequate federal participation in public relations activities connected with FMSA and COFRDA.

Achievements

Participated in an evaluation of FMSA; in cooperation with OMNR and the Ontario Ministry of Treasury and Economics (OMTE) completed negotiations for the new 5-year COFRDA; established technical committees for COFRDA, implementation systems, and relations with outside agencies in the private sector; initiated necessary program procedures and began development of a management information system.

Goals for 1985-1986

To manage efficiently the final year's programs for FMSA and prepare a summary report on the Agreement; to manage COFDRA effectively through cooperation with OMNR and private sector agencies; to complete a program and procedures manual and an electronic support system for COFRDA; to implement a field monitoring program for COFRDA.

EMPLOYMENT STIMULATION

Professional Staff: D.W.J. McGowan (Project Leader), A.J.F. Baliak, R.L. Macnaughton

Objectives

To provide job opportunities in the forest sector that will maximize the training and employment benefits of participants and support the overall thrust of the Forest Sector Strategy for Canada.

Achievements

Through the Environment 2000 (E-2000) Program approved a total of 108 projects providing 21,000 weeks of work for some 1,345 participants; conducted intensive field and financial monitoring programs for E-2000; prepared a final report on the Unemployment Insurance Job Creation Program - Forestry Sector (UI/JCP-FS); oversaw the contract evaluation of the Indian sector of UI/JCP-FS; started to prepare the final report for E-2000.

Goals for 1985-1986

To complete the final report for E-2000; to implement and administer a new employment stimulation program so as to maximize both employment and forestry benefits.

Administration, Financial Services and Property Management

ADMINISTRATION, FINANCIAL SERVICES AND PROPERTY MANAGEMENT

Staff: M.J. Parent, Chief (1985) (R.M. Dean, 1984)
T. Ames, E.L. Baxter, W. Borland, Y. Chartrand, W. Clarke, L.M. Cormier, D. Evoy, D.W. Gair, J. Graham, R.J. Graham, C. Halliday, A. Jones, J.C. Kimball, G.A. King, L.J. Koivisto, J. Lang, J. Longo, H.J. Logtenberg, S. MacLeod, B. McBain, B.I. McKay, G. McLeod, M. Mills, R. Moffatt, E. Morningstar, C. Novick, J. Novick, K. Pelletier, S. Phillips, M.G. Pinder, D.C. Reid, M. Skouris, D.I. Sloan, E.C. Steinke, F.C. Stewart, M.T. Stone, J. Theriault, D.G. Weeks, A. Wills, A. Zurby

Objectives

To provide administrative and financial services for GLFRC, and to operate and maintain the physical plant and grounds.

Achievements

Added a Fox 1001 stand-alone text entry device to the word processing section to increase productivity; completed computerization of fleet management; converted the steam heating system in Building A to a hydronic heating system; completed major repairs on the outdoor cooling tower; introduced new financial reports to provide management with better financial information.

Goals for 1985-1986

To computerize inventory control and materiel management activities; to upgrade two Micom systems by including a spelling package and Infotec, and to purchase an additional Micom unit for word processing; to computerize office equipment and furniture inventories; to develop a maximum/minimum stores system; to streamline financial changes necessitated by the transfer to Agriculture Canada; to monitor financial and human resources effectively; to continue upgrading the fleet within budgetary constraints; to review and revise the functions of personnel so as to enhance productivity and provide better support for programs.

Biometrics and Applied Software Service and Computer Facilities and Services

BIOMETRICS AND APPLIED SOFTWARE SERVICE AND COMPUTER FACILITIES AND SERVICES

Professional Staff: N. Bailey, D.W. Beilhartz, J.E. Field, I.M-J. Kwain

Support Staff: D.M. Grave

Objectives

To provide complete biometrics services, including advice on all aspects of data gathering, assistance in data entry, scientific data processing and analysis, and training for staff in the use of software packages; to acquire and maintain software packages; to plan and maintain the computer system, related equipment, system software and communications facilities; to provide advice on and acquire microcomputers and equipment interfacing with the central computer; to provide technical support for and training on computing and communications facilities; to provide computer graphics services.

Achievements

Acquired a statistical analysis software package (SAS) and a fourth generation data management software package (INGRES); developed a fleet management software package; developed an equipment inventory storage and retrieval system for administration; introduced personal computers in management and administration and started training in their use; installed the DEC VAX 750 computer upgrade and additional equipment and software, and transferred information from the previous system to the new system; acquired an integrated voice/data PBX to replace the current telephone systems and provide data communications internally for the VAX computer, terminals, microcomputers and word processors, and externally through centralized telecommunication facilities; installed additional terminals, printers and microcomputers, installed additional modems for data communications and interfaced word processor data collection equipment with the VAX.

(continued)

Goals for 1985-1986

To develop and coordinate the use of personal computers in administration and management; to design and implement a management information system to assist in monitoring COFRDA; to install, and initiate major program development with, SAS and INGRES; to improve accessibility to computer resources through new acquisitions and utilization of the SL-1 communications system; to install and interface the voice/data PBX with the VAX computer, manage the facilities, and provide training in their use; to increase graphics capabilities through acquisition of graphics digitizing, plotting, display and development/production peripherals; to replace outmoded system peripherals; to continue to manage computer and data communications facilities and assist staff in their use.

Research and Technical Support Services

RESEARCH AND TECHNICAL SUPPORT SERVICES

Staff: C.L. Bodley (Electronics Technician), S.B. Burt (Librarian), N.J. Dukes (Library Clerk), M. Laporte (Greenhouse Technician), J.R. Ramakers (Chemical Analysis Laboratory Technician), E.R. Rayner (Photographer)

Objectives

To provide efficient and economical research and technical support services to GLFRC.

Achievements

Purchased a Kjeltec Nitrogen Analyzer and a Dionex Ion Chromatograph for SO_4 analyses and increased productivity in the analytical services laboratory by 25%; constructed 12 additional rate-of-spread Digital timers for fire research field trials, converted three VT100 terminals to graphics capability for computer facilities and services, installed two mobile radios for FIDS staff, and serviced and maintained 167 units of electronic analytical instrumentation; provided photographs for displays, duplicated video tapes for use by staff and recorded on film the progress of the Centre's expansion program; maintained greenhouse services to meet program needs; updated the library's serials holdings list and assisted OMNR in training two Katimavik students in the organization of a small collection.

Goals for 1985-1986

To integrate acid rain soil and plant samples from permanent growth plots into the analysis program and improve methodology for SO_4 analysis in foliage; to develop a color printing capability and a video production capability; to maintain greenhouse services; to design and construct electronic equipment as required for the Centre's projects; to monitor computer search services and establish accounts with QL Systems and the Bibliographic Retrieval System if this seems advisable; to investigate the feasibility of accessing an on-line forestry data base being developed by the United States Forest Service; to implement the use of ENVOY 100 to improve interlibrary loan service.

Scientific and Technical Information Services

SCIENTIFIC AND TECHNICAL INFORMATION SERVICES

Professional Staff: C.A. Plexman (Unit Head), J.C. Lalonde

Support Staff: P. Jakibchuk, D.J. Kennington, D. Murphy, M.K. Rouse

Objectives

To publish and disseminate scientific and technical information issuing from the Centre's programs and to promote an understanding of the wide use of forest resources among the general public; to increase public awareness, appreciation and understanding of Canada's forested environment through personal experience; to cooperate with the provincial government in implementing the communications activities outlined in COFRDA; to promote the activities of the research centre among all sectors of the public.

Achievements

Published over 120 scientific papers and reports, and issued various newsletters and bulletins; issued over 35 news releases; participated in the Sault Ste. Marie Board of Education Cooperative education program; completed a number of major projects for National Forest Week, including an Open House and visit by the Minister of the Environment; published and distributed a new brochure on the research centre's program and services, and a biographical booklet on professional staff; participated in the planning and implementation of communications activities for the FMSA and COFRDA; handled public relations for the Environment 2000 program; introduced two new publication series, the Joint Report and Miscellaneous Report series; organized and conducted public tours; participated in various forestry exhibitions; opened the forest ecology trail to the public, and maintained and improved existing facilities; planted 25 trees and 22 shrubs in the arboretum; prepared an inventory of public information materials produced by the Centre.

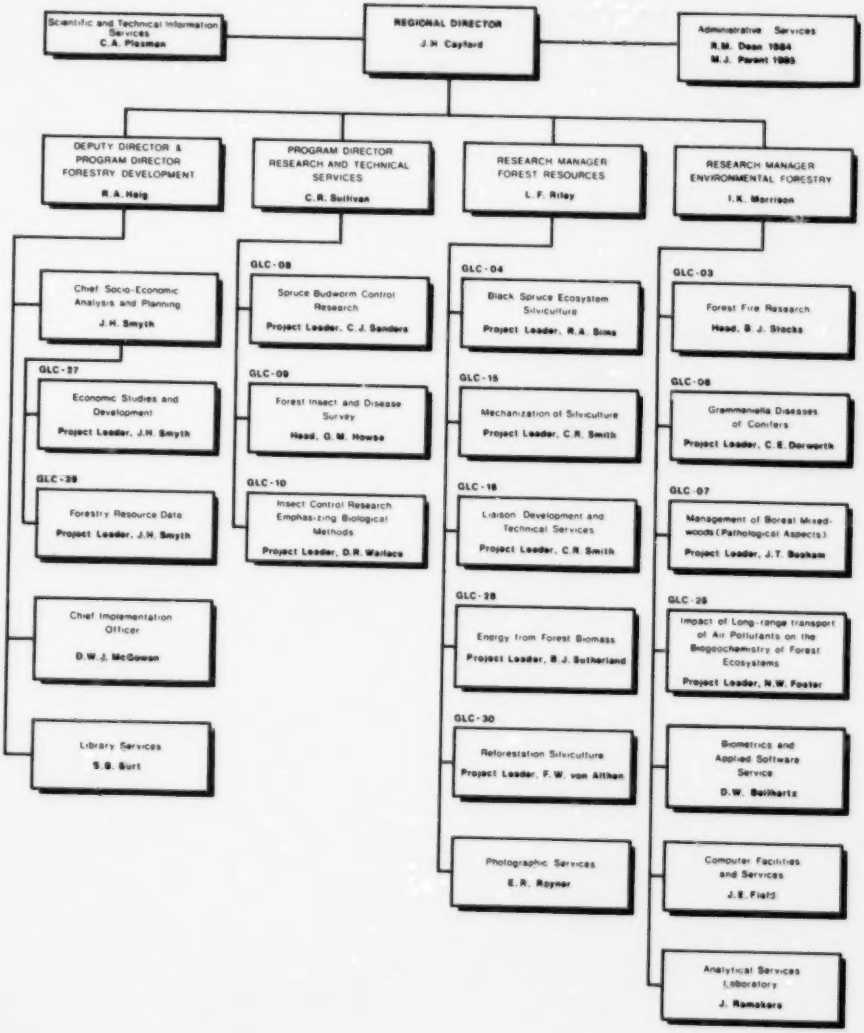
Goals for 1985-1986

To continue publishing and disseminating information issuing from the Centre's programs; to plan and implement communications activities for COFRDA; to computerize a number of information office functions; to establish a communications network throughout Ontario's forestry community; to continue the summer tour, arboretum planting and forest ecology trail programs; to train two new Information Officers; to participate in various forestry exhibitions; to integrate library and information services within a Communications Services Unit.

Appendices

GREAT LAKES FOREST RESEARCH CENTRE

ORGANIZATION CHART



EXPENDITURES
($'000)

Project	Person years	Salaries	Operations and maintenance	Capital	Grants and contributions	Total
Forest Environment Research						
Impact of Long-range Transport of Air Pollutants on the Biogeochemistry of Forest Ecosystems	7.5	239.3	168.4	3.7		431.4
Forest Production Research						
Black Spruce Ecosystem Silviculture	13.5	468.8	65.8	17.4		552.0
Mechanization of Silviculture	5.0	195.8	26.3	1.1		223.3
Reforestation Silviculture	9.5	370.5	53.1	5.3		428.9
Forest Protection Research						
Forest Fire Research	6.0	206.2	36.6	11.9		254.7
Cronmoniella Diseases of Conifers	4.0	166.8	24.6	8.7		200.1
Boreal Hinadwood Pathology	5.0	181.8	20.0	10.3		212.1
Spruce Budworm Control Research	6.0	228.2	49.6	4.3		282.1
Insect Control Research Emphasizing Biological Methods	6.0	223.2	35.0	18.0		276.2
Forest Utilization Research						
Energy from Forest Biomass	.5	19.9		1.2		21.1
Forestry Services						
Forest Insect and Disease Survey	27.0	864.5	117.9	20.7		1,003.1
Forest Resources Data	1.5	29.2	2.5			31.7
Liaison, Development and Technical Services	1.0	39.7	12.1			51.8
Forestry Development						
Economic Studies and Development	3.5	131.6	10.0	.8		142.4
Development Agreements	3.0	129.8	31.1		5,801.1	5,962.0
Employment Stimulation	7.0	177.3	85.6	80.0	13,978.0	14,320.9
Management	8.0	363.8	70.2			434.0
Administration, Financial Services and Property Management	42.6	904.3	920.3	210.9		2,035.5
Biometrics and Applied Software Service and Computer Facilities and Services	5.0	149.2	69.7	69.7		288.6
Technical Support Services	6.0	191.4	65.6	11.6		268.6
Scientific and Technical Information Services	5.0	115.7	57.5	3.4		176.6
TOTALS:	172.6	*5,417.0	**1,921.9	479.0	19,779.1	27,597.0
*DCIP salaries not included		108.9				
**PSUP contract not included			203.8			

CONTRACTS LET OR SUPERVISED BY THE GREAT LAKES FOREST RESEARCH CENTRE
FOR THE YEAR 1984-85

Contractor's Name	Contract Title	Contract Amount
University of Toronto	Determination of the toxicity of aluminum to the root system of boreal forest tree species	$ 16,282
University of Waterloo	Analysis of growth and yield data according to prescribed procedures	$ 937
University of Waterloo	Analysis of growth and yield data for computer software	$ 5,276
Matcom Forestry Consultants	Ecological assessment of strip cutting in upland black spruce	$ 9,998
Research and Productivity Council	Chemical identification of secondary components of the spruce budworm	$ 14,883
Art Jalkanen	Collection of soil and water samples	$ 2,709
University of Waterloo	Analysis of research data according to prescribed procedures	$ 936
Ecologistics Ltd.	Forestry analysis of ULJC programs	IRAC $ 21,500 GLFRC $ 1,500
University of Waterloo	Analysis of research data according to prescribed procedures	$ 5,277
R.C. McPhee	Data collection to assure the continuity of the study of 8 provenances of jack pine to evaluate their suitability for Christmas tree culture	$ 1,500
University of Guelph	Analyze plant samples for 15 nitrogen content	$ 3,861
Lakehead University	Application of probability distribution as a tool for predicting yields of immature black spruce and jack pine plantations	$ 18,212[a]
University of Toronto	Manipulation of the host pathogen system to control Armillaria root rot	$ 23,000[a]
University of Toronto	Prediction of people-caused forest fire occurrence	$ 32,928[a]
University of Waterloo	Drought tolerance and the physiological mechanisms of resistance in northern coniferous seedlings	$ 21,800[a]
University of Toronto	Evaluation of site preparation tools on difficult full-tree logged sites	$ 33,940
Lakehead University	The identification of bacterial isolates from seedlings	$ 20,000[a]
University of Saskatchewan	Development of an active seat suspension system for off-load forestry vehicles	$ 53,277[a]
Kimo Design	Lease agreement for rental of a Universal Co-tract carrier	$ 33,615[b]
Kimo Design	To fabricate a brushwood harvester head c/w chipper and chipper conveyor assembly	$ 35,587[b]
Forest Engineering Research Institute of Canada	Development of a system to process biomass residues from full tree processing. Phase I, II, III	$143,346[b]

(continued)

CONTRACTS LET OR SUPERVISED BY THE GREAT LAKES FOREST RESEARCH CENTRE FOR THE YEAR 1984-85 (concluded)

Contractor's Name	Contract Title	Contract Amount
Forest Engineering Research Institute of Canada	To field test experimental prototype roll splitter	$ 44,358[b]
Elmo Design	Field trials of Crabe combine brush harvester	$105,424[b]
Matcam Forestry Consultants	Field assessment of Crabe combine brush harvester	$ 47,314[b]
Ilkka Koivisto	Development and demonstration project "peatland drainage for forestry purposes in the claybelt of Northern Ontario"	$ 47,600[b]
Forest Engineering Research Institute of Canada	The effects of selected harvesting methods in jack pine on energy biomass yield and truck load characteristics	$28,905[b]
R.S.W. Robbetts	Ecological inventory and description of certain fast disappearing wetland types	$ 26,650[b]
Forest Engineering Research Institute of Canada	Transportation of full trees on public roads	$119,933[b]
Forest Engineering Research Institute of Canada	Evaluation of forest biomass compaction systems	$ 43,450[b]
George Rhidmore	To construct two complete weirs	$ 14,867[b]
Montreal Engineering Co.	Literature review to evaluate techniques for increasing biomass production on peatland in Ontario	$ 38,575[b]
Matcam Forestry Consultants	Compilation of Crabe combine assessment data	$ 6,500[b]
Hunter & Associates	Collect foliar data from stands in Wally Creek Watershed	$ 6,750[b]

[a]PERD = Program of Research by Universities in Forestry
[b]EMPOR = Energy from the Forest
EMPOR and Post Forum funds are provided under the federal government's Program for Energy Research and Development (PERD).

PUBLICATIONS

ANON. 1984. Program Review, Great Lakes Forest Research Centre, 1983-84. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. 60 p.

BARNES, C.A. and EVANS, H.J. 1984. Results of forest insect and disease surveys in the Southwestern Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 7. 27 p.

Barteaux, M.K. and Bailey, R.E. 1984. Status report on the management of jack pine in the provinces of New Brunswick and Nova Scotia. p. 14-19 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

BASHAM, J.T. 1984. Degradation and loss of wood fibre in spruce budworm-killed timber, and effects on utilization. For. Chron. 60(1):10-14.

Beckwith, A.F., Roebbelen, P. and Pessione, S. 1984. Variable-density growth and yield of managed jack pine plantations. p. 145-156 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

BIGGS, W.D. and JANSONS, V. 1984. Results of forest insect and disease surveys in the North Central Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 2. 30 p.

BRODERSEN, H. and LAWRENCE, H.D. 1984. Results of forest insect and disease surveys in the Algonquin Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 5. 25 p.

Brown, G. 1984a. Aerial seeding of wildfire areas in the Northwestern Region. p. 93-101 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFR Symp. Proc. O-P-12.

Brown, G. 1984b. Overview of management options for jack pine in Ontario. p. 185-187 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Brown, G. 1984c. The performance of 1-0 jack pine bare-root stock under field conditions. p. 53-55 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Brown, G. 1984d. Site preparation standards and measurements. p. 62-65 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Clark, A. Ground seeding requirements for jack pine regeneration. p. 87-92 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Couture, G. and Dancause, A. 1984. Status report on the management of jack pine in the province of Quebec. p. 29-37 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

DAVIS, C.N. and DORWORTH, C.E. 1984. The fungus that causes Scleroderris canker survives field exposure in plastic bags. Tree Plant. Notes 35(1):18-19.

Davison, R.W. 1984. Jack pine management in the boreal forest of Ontario. North Central Region. p. 169-172 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Dennis, R. 1984. Vegetation management in jack pine plantations. p. 116-121 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

EVANS, H.J., BARNES, C.A., LAWRENCE, H.D. and WEIR, H.J. 1984. Results of forest insect and disease surveys in the Central Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 6. 31 p.

FLEMING, R.L. and Crossfield, R.M. 1983. Strip cutting in shallow-soil upland black spruce near Nipigon, Ontario. III. Windfall and mortality in the leave strips: preliminary results. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-334. 27 p. + Appendix.

FLEMING, R.L. and Lister, S.A. 1984. Stimulation of black spruce germination by osmotic priming: laboratory studies. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-362. 15 p. + Appendix.

Galloway, R.L. 1984. Jack pine regeneration in the Northern Region. p. 173-176 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

GARDINER, L.F. 1984. Today's challenge...forests for the future. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. Leaflet. Aussi disponible en français sous le titre "Le défi d'aujourd'hui: des forêts pour demain".

GROOT, A. 1984. Stand and site conditions associated with abundance of black spruce advance growth in the Northern Clay Section of Ontario. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-358. 15 p.

GROOT, A., Brown, K.M., MORRISON, I.K. and Barker, J.E. 1984. A 10-year tree and stand response of jack pine to urea fertilization and low thinning. Can. J. For. Res. 14(1):44-50.

GROSS, H.L. 1983. Negligible cull and growth loss of jack pine associated with globose gall rust. For. Chron. 59(6):308-311.

GROSS, H.L. 1984a. Defect associated with Eutypella canker of maple. For. Chron. 60(1):15-17.

GROSS, H.L. 1984b. Impact of Eutypella canker on the maple resource of the Owen Sound and Wingham forest districts. For. Chron. 60(1):18-21.

GROSS, H.L., Ek, A.R. and Patton, R.F. 1983. Site character and infection hazard for the sweetfern rust disease in northern Ontario. For. Sci. 29(4):771-778.

HAAVISTO, V.F. and JEGLUM, J.K. 1984. Forestry study tour of Finland. Can. For. Ind. 104(5):38-41.

Heikurinen, J. 1984. Review of the jack pine regeneration program in the Northeastern Region. p. 177-184 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Horton, K.W. 1984. Mechanizing cone collection of black spruce in Ontario. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. Joint Rep. No. 2 (Published in cooperation with the Ontario Ministry of Natural Resources). 16 p.

HOWSE, G.M. 1984. Insect pests of jack pine: biology, damage and control. p. 131-138 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

HOWSE, G.M. and APPLEJOHN, M.J. 1984. Forest insect and disease conditions in Ontario, 1983. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 16. 53 p.

HOWSE, G.M., Nicholson, S.A. and MEATING, J.H. 1983. Operational use of *B.t.* against spruce budworm in Ontario, 1979-1983. p. 5-22 *in* J.R. Carrow, *Ed. B.t.* and the Spruce Budworm 1983. Proc. of seminar, Fredericton, N.B., 8 September 1983. N.B. Dep. Nat. Resour., Fredericton.

Hutchinson, R.E. 1984. Bare-root jack pine: lifting, holding and storage period. p. 107-111 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

INGRAM, W.A. 1984. Results of forest insect and disease surveys in the Eastern Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 8. 33 p.

JEGLUM, J.K. 1983. Changes in tree species composition in naturally regenerating strip clearcuts in shallow-soil upland black spruce. p. 180-193 *in* R.W. Wein, R.R. Riewe and I.R. Methven, *Ed.* Conf. Proc. Resources and Dynamics of the Boreal Zone, Thunder Bay, Ont., Aug. 1982. Assoc. Can. Univ. for Northern Studies.

JEGLUM, J.K. 1984. Strip cutting in shallow-soil upland black spruce near Nipigon, Ontario. IV. Seedling-seedbed relationships. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-359. 26 p.

JEGLUM, J.K., HAAVISTO, V.F. and GROOT, A. 1983. Peatland forestry in Ontario: an overview. p. 127-167 *in* J.D. Sheppard, J. Musial and T.E. Tibbetts, *Ed.* Symposium 82, a symposium on peat and peatlands. Sponsored by Gov't. of Can., Gov't. of N.B., Econ. Expans. Comm. of the Peninsula Inc., and Can. Nat'l. Comm., Internat'l. Peat Soc.

JOHNSON, J.D. 1984. Effect of tariff reductions on the Canadian fine paper industry. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 15. 19 p.

KELLY, B. and RÉGNIÈRE, J. 1985. Predation on pupae of the spruce budworm (Lepidoptera: Tortricidae) on the forest floor. Can. Ent. 117: 33-38.

Kennedy, F.D. 1984. Jack pine regeneration in the Northwestern Region. p. 163-168 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Little, M.T. 1984. Status report on the management of jack pine in the province of Saskatchewan. p. 20-24 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Symp. Proc. O-P-12.

LUCUIK, G.S. 1984. Effect of climatic factors on post-diapause emergence and survival of spruce budworm larvae (Lepidoptera: Tortricidae). Can. Ent. 116:1077-1083.

LYONS, D.B. and Van Baren, B. 1984. Comparison of the olfactometric response of *Hylurgopinus rufipes* and *Scolytus multistriatus* (Coleoptera: Scolytidae) to the synthetic pheromone Multilure® and its components. Gov't. of Can., Can. For. Serv., Ottawa, Ont. CFS Res. Notes 4(4):50-51.

MacLEOD, L.B., JONES, C.G. and KEIZER, A.J. 1984. Results of forest insect and disease surveys in the Northern Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 3. 37 p.

McGauley, B.H. and GROSS, H.L. 1984. Jack pine diseases in Ontario. p. 139-144 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

McIntyre, J.M. 1984. Jack pine seed collection, extraction and management in the Northwestern Region of the Ontario Ministry of Natural Resources. p. 47-52 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Moore, W.S. 1984. Keynote address: status and potential of jack pine in Ontario. p. 1-8 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

MORRISON, I.K. 1984. Acid rain: a review of literature on acid deposition effects in forest ecosystems. For. Abstr. 1984 Vol. 45, No. 8.

MORRISON, I.K. 1984. Acid rain, forests and forestry. p. 209-219 *in* E.L. Stone, *Ed.* Forest soils and treatment impacts. Proc. Sixth North. Am. For. Soils Conf., Knoxville, Tenn., June 1983.

Miller, L.K. 1984. Northern Region jack pine tree improvement program. p. 157-162 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Müller, E. and DORWORTH, C.E. 1963. On the discomycetous genera *Ascocalyx* Naumov and *Gremmeniella* Morelet. Sydowia XXVI:193-203.

PAYANDEH, B. 1984. Dimensional relationships for several tree species from the spruce-fir types of northwestern Ontario. Dep. Environ., Can. For. Serv., Ottawa, Ont. CFS Res. Notes 4(2):18-20.

Pletch, M. 1984. Transportation, holding and planting of jack pine. p. 112-115 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

PLEXMAN, C.A. 1978. Trees of Ontario: the pines. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (reprinted 1984) (aussi disponible en français sous le titre "Les arbres de l'Ontario: le pin").

PLEXMAN, C.A. 1984. 1984 supplement to bibliography of Great Lakes Forest Research Centre publications. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. 21 p. + Appendix.

Reese, K.H. 1984. Stock production standards for bare-root and container jack pine. p. 102-105 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

RÉGNIÈRE, J. 1984. Vertical transmission of diseases and population dynamics of insects with discrete generations: a model. J. Theor. Biol. 107:287-301.

RÉGNIÈRE, J. and SANDERS, C.J. 1983. Optimal sample size for the estimation of spruce budworm (Lepidoptera: Tortricidae) populations on balsam fir and white spruce. Can. Ent. 115:1621-1626.

RICHARDS, W.C. and TAKAI, S. 1984. Characterization of the toxicity of cerato-ulmin, the toxin of Dutch elm disease. Plant Pathol. 6:291-298.

ROSE, A.H. and LINDQUIST, O.H. 1975. White pine weevil. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (reprinted 1984).

ROSE, A.H. and LINDQUIST, O.H. 1976a. European pine sawfly. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (revised and reprinted 1984).

ROSE, A.H. and LINDQUIST, O.H. 1976b. Redheaded pine sawfly. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (reprinted 1984).

ROSE, A.H. and LINDQUIST, O.H. 1978. Forest tent caterpillar. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (revised and reprinted 1984) (aussi disponible en français sous le titre "La livrée des forêts").

ROSE, A.H. and LINDQUIST, O.H. 1980. Spruce budworm. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (revised and reprinted 1984) (aussi disponible en français sous le titre "Tordeuse des bourgeons de l'épinette").

Rudolph, T.D. 1984. Status report on the management of jack pine in the Lake States. p. 38-46 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

SAJAN, R. and CONSTABLE, D.C. 1984. Results of forest insect and disease surveys in the Northwestern Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 1. 41 p.

SANDERS, C.J. 1984b. Sex pheromone of the spruce budworm (Lepidoptera: Tortricidae): evidence for a missing component. Can. Ent. 116: 93-100.

SCARRATT, J.B. 1984. Considerations in the selection of a growing medium for the aerial dart seeding system. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-360. 22 p. + appendices.

SIPPELL, W.L. 1983. Continuous evaluation and reporting of a changing spruce budworm damage picture in Canada. Spruce Budworm Implementation Plan, Activity A, Working Group A4/A5. Dep. Environ., Can. For. Serv., Ottawa, Ont.

SIPPELL, W.L. 1984. Planning now to reduce, postpone or prevent the next spruce budworm outbreak. p. 59-67 *in* Proceedings: New and Improved Techniques for Monitoring and Evaluating Spruce Budworm Populations. Sponsored by Vermont Dep. Forests, Parks and Recreation, USDA For. Serv., State and Private Forestry, CANADA/U.S. Spruce Budworms R & D Prog., 13-15 Sept. 1983, Burlington, Vt. Gen. Tech. Rep. NE-88.

Smith, B.W. 1984. Aerial seeding requirements for jack pine regeneration. p. 78-86 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

SMITH, C.R. 1984a. Precommercial thinnings in jack pine with particular reference to experiments in northeastern Ontario. p. 122-130 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

SMITH, C.R. 1984b. Status of mechanization of silviculture in Canada. p. 41-49 *in* Mechanization of silviculture: increasing quality and productivity. Proc. CPPA/CFS Seminar on Mechanization of Silviculture, 17 Sept. 1984, Thunder Bay, Ont. Can. Pulp Pap. Assoc., Woodlands Sect., Montreal.

SMITH, C.R. and Brown, G., *Cochairmen*. 1984. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12. 195 p.

SMYTH, J.H. and BROWNWRIGHT, A.J. 1984. Forest tree production centres in Canada - 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-357. 45 p. + appendices.

SMYTH, J.H. and RAMSAY, K.L. 1984. Selected forestry statistics--Ontario, 1984. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 12. 104 p.

SMYTH, J.H., RAMSAY, K.L. and Barron, D.E. 1984. Forest management expenditures in Canada 1977-1981. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Joint Rep. No. 1 and Inf. Rep. W.S. Index 2918 (F-11) (Canadian Pulp and Paper Association). 99 p. (aussi disponible en francais sous le titre "Depenses en amenagement forestier 1977-1981").

STOCKS, B.J. and Street, R.B. 1983. Forest fire weather and wildfire occurrence in the boreal forest of northwestern Ontario. p. 249-265 *in* R.W. Wein, R.R. Riewe and I.R. Methven, *Ed.* Conf. Proc. Resources and Dynamics of the Boreal Zone, Thunder Bay, Ont., Aug. 1982. Assoc. Can. Univ. for Northern Studies.

SUTHERLAND, B. 1984. The essential component of silvicultural equipment assessment. p. 61-66 *in* Mechanization of silviculture: increasing quality and productivity. Proc. CPPA/CFS Seminar on Mechanization of silviculture, 17 Sept. 1984, Thunder Bay, Ont. Can. Pulp Pap. Assoc., Woodlands Sect., Montreal.

SUTTON, R.F. 1984. Bare-root planting season options. For. Chron. 60(6): 328-334.

SUTTON, R.F. 1984a. Mounding site preparation: evaluation of jack pine outplantings in a boreal Ontario study. p. 66-77 *in* C.R. SMITH and G.H. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

SUTTON, R.F. 1984b. Plantation establishment in the boreal forest: glyphosate, hexazinone, and manual weed control. For. Chron. 60(5):283-287.

SYME, P.D. 1984. Jack pine budworm. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. GLFRC leaflet. 2 p. (produced in cooperation with the Ontario Ministry of Natural Resources) (aussi disponible en français sous le titre "Tordeuse du pin gris").

TAKAI, S. and Hiratsuka, Y. 1984. Scanning electron microscope observations of internal symptoms of white elm following *Ceratocystis ulmi* infection and cerato-ulmin treatment. Can. J. Bot. 62:1365-1371.

Ternent, L.K. 1984. Cutover site classification for site preparation. p. 56-61 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

THOMSON, M.J., CZERWINSKI, E.J., MacLEOD, L.S. and JANSONS, V. 1984. Results of forest insect and disease surveys in the Northeastern Region of Ontario, 1983. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 4. 39 p.

VON ALTHEN, F.W. 1984. Mowing versus mechanical or chemical weed control in sugar maple afforestation. Tree Plant. Notes 35(3):28-31.

WEBB, D.P. and Reese, K.H. 1984. Multiple leadering of coniferous nursery stock. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. Joint Rep. No. 3 (Published in cooperation with the Ontario Ministry of Natural Resources). 8 p.

WEIR, H.J., THOMSON, M.J., CONSTABLE, D.C. and JONES, C.G. 1984. A review of important forest insect and disease problems in the Espanola District of Ontario, 1950-1980. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 10. 152 p. + appendices.

WEIR, H.J., THOMSON, M.J., CONSTABLE, D.C. and JONES, C.G. 1984. A review of important forest insect and disease problems in the Sault Ste. Marie District of Ontario, 1950-1980. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 9. 143 p. + appendices.

WEIR, H.J., THOMSON, M.J., CONSTABLE, D.C. and JONES, C.G. 1984. A review of important forest insect and disease problems in the Sudbury District of Ontario, 1950-1980. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 12. 149 p. + appendices.

WEIR, H.J., THOMSON, M.J., CONSTABLE, D.C. and JONES, C.G. 1984. A review of important forest insect and disease problems in the Wawa District of Ontario, 1950-1980. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Misc. Rep. No. 11. 113 p. + appendices.

WOOD, J.E. 1983. Five-year comparison of jack pine bare-root, Ontario tube, and paperpot seedlings. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-355. 13 p. + Appendix.

WOOD, J.E. 1984a. Black spruce outplantings in Ontario's Clay Belt. Bare-root versus paperpot stock: five-year results. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-356. 11 p. + Appendix.

WOOD, J.E. 1984b. Preliminary investigation of the field performance of black spruce rooted cuttings in boreal Ontario. Dep. Environ., Can. For. Serv., Ottawa, Ont. CFS Res. Notes 4(2):1820.

WOOD, J.E. and COLOMBO, S.J., *Comp.* 1984. A registry of containerized tree seedling research in Ontario: 1982-1983. Gov't. of Can., Can. For. Serv., Sault Ste. Marie, Ont. Joint Rep. No. 4. 23 p. + appendices. (produced under the auspices of the Canada-Ontario Joint Forestry Research Committee).

WOOD, J.E. and JEGLUM, J.K. 1984. Black spruce regeneration trials near Nipigon, Ontario: planting versus seeding, lowlands versus uplands, clearcut versus strip cut. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. Inf. Rep. O-X-361. 19 p.

Yarn, L.G. 1984. Status report on the management of jack pine in the province of Manitoba. p. 25-28 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.

Yeatman, C.W. 1984. The genetic basis of jack pine management. p. 9-13 *in* C.R. SMITH and G. Brown, *Cochairmen*. Jack pine symposium. Dep. Environ., Can. For. Serv., Sault Ste. Marie, Ont. COJFRC Symp. Proc. O-P-12.